Boltzmann Fluid Dynamics

A remarkably accurate technique for simulating the dynamic motion of solid particles in suspension

Many of today's high-technology products involve coatings of particulate solids; these include coatings for hulls of ships and submarines, nonreflective coatings for aircraft, television screens, magnetic media for computers (disks and tapes), and photographic film. Improving the performance of these coatings often involves the search for better uniformity and control of the coating process.

Simulating fluid flows

An accurate and efficient computer simulation method applicable to dense colloidal suspensions both at equilibrium and under shear can greatly facilitate the complex task of optimizing the design and processing of coatings. Our numerical method is based on a relatively new approach to computational fluid dynamics, the lattice Boltzmann equation.

Boltzmann fluid dynamics (BoF) is a numerical algorithm for simulating fluid flow by solving a discretized (lattice) Boltzmann equation. It is especially suitable for flows in complex geometries, which are still exceedingly difficult to simulate using conventional finite-difference or finite-element methods.

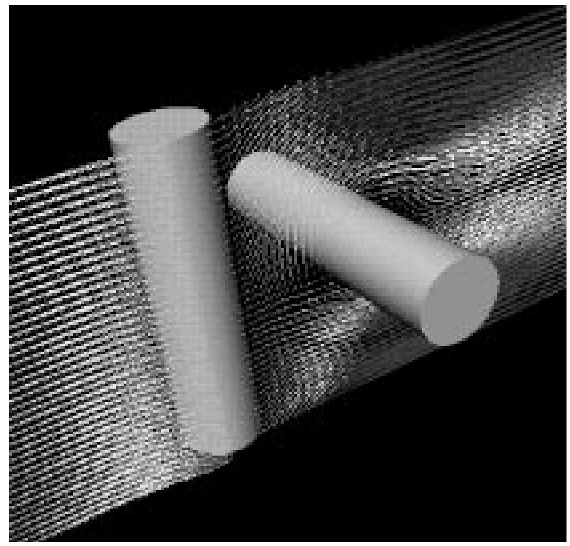
The code can be applied to fluid flows in almost any solid matrix; recent applications include fractal porous media and wire filters. However, the primary application involves particle suspensions. The code can track the motion of many hydrodynamically-interacting particles, for instance in sedimentation. It has also been used to study Brownian motion in concentrated suspensions of sub-micron-sized spheres.

APPLICATIONS

- *Photographic imaging*
- *Industrial coatings*
- *Specialized paints*
- *High-resolution television screens*
- *Magnetic media for computers*

Critical technology

Precision coating is a critical technology area in which the United States is weak. The use of very sophisticated materials is being hindered by a lack of understanding of how they flow. The work at LLNL will result in reliable computational modeling tools applicable to realistic engineering problems associated with coating processes. The development of these numerical simulations will also have significant impact on the science of complex fluids, such as particulate suspensions and polymer solutions. The work also builds on LLNL's traditional strength and excellence in using powerful computers to solve complex problems of practical importance.



Flow across two cylinders at a T-junction.

Availability: The Boltzmann fluid dynamics simulation code is in research and development but has been validated by extensive numerical tests. The present version of the code can simulate between 100 and 1000 solid spheres on a desktop workstation. A parallel version of the code, being developed for LLNL's new Meiko supercomputer, will simulate tens of thousands of spheres.

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